



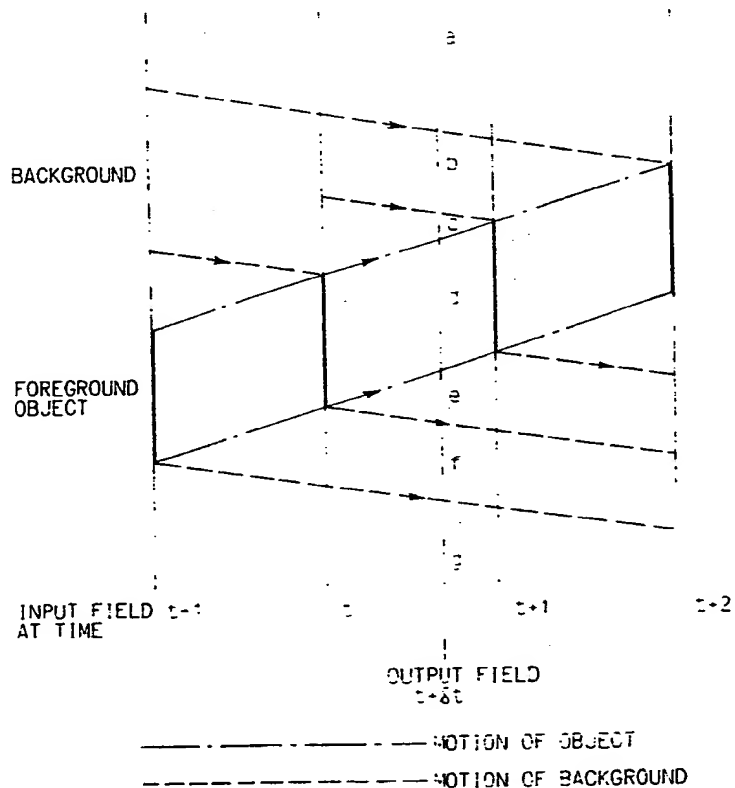
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(54) Title: VIDEO IMAGE PROCESSING

(57) Abstract

The appropriate one of a list of possible motion vectors is applied to each region of a video image. An image value for that region is determined for each of four successive fields, for each of the possible motion vectors. The values for the four fields are compared and when the values are substantially the same for a given vector it is assumed that that is the vector appropriate to that region. The vectors appropriate to regions of obscured or revealed background can also be assigned by comparing inter-field differences and determining regions where the inter-field differences are high for the central pair and one outer pair and low for the other outer pair of fields. To generate regions corresponding to obscured background only information from the earlier fields is used and to generate regions corresponding to revealed background only information from the later fields is used.



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Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

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VIDEO IMAGE PROCESSING

Background of the Invention

This invention relates to video image processing, and more particularly to the assigning of motion vectors indicating the direction and magnitude of apparent movement to different regions of the image, to assist in the generation of desired output images.

Our United Kingdom Patent No. GB-B-2,188,510 and BBC Research Department Report RD 1987/11 describe a method of processing a video image so as to provide a list of motion vectors which are applicable over the whole area and one of which may be regarded as applying to each region of the image. Other methods are also possible for generating such a list of motion vectors. To use such vectors it is then necessary to select which of these vectors may apply to given regions of the picture. Each region may be as small as a picture element (pixel) or it may comprise a plurality of picture elements or a block of the picture.

The motion vectors may be used, for example, to generate output fields which correspond to an instant in time which lies intermediate the time of two input fields. This may be required for instance in producing slow motion effects, in transferring video images to or from film, or in standards conversion.

One of the most challenging applications of motion compensation is to generate slow-motion sequences without the jerky motion that results from simply repeating each image a number of times. Knowledge of the motion vector of each object in the image allows new images corresponding to any time instant to be generated showing the objects correctly positioned. The use of such a technique in conjunction with a shuttered CCD camera should allow sharp smoothly-moving pictures to be generated with a quality approaching that obtainable from a high frame-rate camera, without the operational problems that the use of such a camera would entail.

A typical image may be regarded in its simplest form as having a moving foreground region and a background region, as illustrated somewhat diagrammatically in Figure 1 of the drawings. At (a) is shown one field of an image comprising a foreground object, such as a ball, in front of a background. At (b) is shown

the next field of the image. The ball will have moved from position A to position B. Looking at image (b), part of the background which was seen in (a) is now obscured, and part of the background which was not seen in (a) is now revealed or uncovered.

In general the background may also be "moving" in the image if, for example, the camera is being panned. Thus motion vectors will be associated both with the foreground and with the background respectively. The appropriate motion vector is chosen in each case from the list of possible motion vectors (which has been produced eg. as described in our aforementioned patent) by comparing the two successive fields and looking at the movement which has taken place over different regions of the image.

This operation will provide accurate information over most of the picture area. Thus the background which is not covered by either image position of the ball, A or B, can be compared between the two images. Also the overlap region covered by both position A and position B of the ball can be compared to provide an appropriate vector. However in both the area of obscured background and the area of revealed or uncovered background, one of the fields contains an image of the ball and the other an image of the background. These can not be meaningfully correlated.

Many motion estimation algorithms have been proposed, see e.g. Proceedings of the International Zurich Seminar on Digital Communications, March 1984, pages D2.1 - D2.5, Bergmann, H.C., "Motion-adaptive frame interpolation". Most can not detect motion in such regions, or can detect such regions only when the background is stationary, but of those that can detect its existence we do not believe that any can determine the direction or magnitude of motion of the region at the time that it disappears from view or when it reappears.

European Patent Application No. EP-A-0 395 264 published 31st October 1990 describes equipment for converting an 1125/60/2:1 HDTV signal into a 24Hz progressive (non-interlaced) format for recording onto film, which uses a motion estimation technique which comprises a two-stage algorithm in which the first stage comprises correlating (by block matching) relatively large areas of the image to determine a list of possible motion vectors, followed by an

assignment process to allocate vectors to individual pixels. In this assignment process, vectors are assigned to pixels in existing input fields, and this information then has to be converted to refer to pixels in desired output fields. Three input frames are used in the comparison.

Summary of the Invention

The present invention is defined in the appended claims to which reference should now be made.

In a preferred embodiment of the invention, an image value for each region of a video image is determined for each of four successive fields, for each one of a list of possible motion vectors. The values for the four fields are compared, and when the values are substantially the same for a given vector, it is assumed that that is the vector appropriate to that region. The vectors appropriate to regions of obscured or revealed background can also be assigned by comparing inter-field differences and determining regions where the inter-field differences are high for the central pair and one outer pair and low for the other outer pair of the group of four fields.

Output fields can be generated by interpolation. To generate regions corresponding to obscured background, only information from the earlier fields is used and to generate regions corresponding to revealed background only information from the later fields is used.

Brief Description of the Drawings

The preferred embodiment of the invention will be described in more detail, by way of example, with reference to the drawings, in which:

Figure 1 (referred to above) shows two successive fields of a sequence of video images in which movement of a foreground object takes place;

Figure 2 is a diagram illustrating corresponding points on four successive fields for a given motion vector;

Figure 3 is a diagram illustrating movement of foreground and background as between the four successive fields;

Figure 4 is a block diagram of apparatus for obtaining four luminance values along a trial motion trajectory;

Figure 5 is a block diagram of apparatus for calculating assignment errors; and

Figure 6 illustrates a circuit for comparing classification codes and errors.

Detailed Description of the Preferred Embodiment

If it is assumed that the whole image is displayed in accordance with the same trial motion vector, that is one of the vectors in the list of possible motion vectors, then the value of any pixel can be estimated by looking back to the point in the previous field which is displaced by the amount of that vector. Alternatively, taking any given field as a datum, one can look backwards and forwards and for each pixel in the datum field generate what value that pixel would be at the time of occurrence of the preceding and subsequent fields. This is achieved by looking at the points in those previous and subsequent fields which are displaced from the pixel in the datum field by an amount appropriate to that motion vector. This operation is illustrated in Figure 2 which diagrammatically illustrates four fields of a video signal at times $t - 1$, t , $t + 1$ and $t + 2$ respectively. On the vertical axis is shown in one dimension a spatial section across the image. Due to motion the points that correspond on the different fields are spatially displaced.

Thus, for any given motion vector, one can build up, for each pixel in the datum field, the values that that pixel is expected to have in a succession of fields. If the motion vector is indeed the correct one for that pixel, those values are likely to be more or less the same. If the operation is repeated for all possible motion vectors, then the vector which produces the least variation in the values obtained is likely to be the appropriate vector for that pixel. The values can be processed to give a measure of assignment error, as described below, for each pixel and each vector.

In accordance with this invention, therefore, we propose using the content of four successive fields to determine the appropriate motion vectors for the various regions of the image. Reference is made to Figure 3 which likewise diagrammatically illustrates four fields of a video signal at times $t - 1$, t , $t + 1$ and $t + 2$ respectively. On the vertical axis is shown in one dimension a foreground object moving over a background which is itself moving. As seen in the figure the foreground object is moving steadily upwards between fields $t - 1$ and $t + 2$ whereas the background is moving more slowly downwards.

Existing systems compare the two central fields t and $t + 1$ and are unable to determine the vector appropriate to certain regions of the image. In particular they are unable to determine the vector appropriate to the region marked c , which represents background which is obscured between fields t and $t + 1$, or the vector appropriate to the region marked e , which represents revealed background.

The motion vectors may be used in an interpolation operation to generate an output field at an instant $t + \delta t$ corresponding to a time intermediate between fields t and $t + 1$. By making use of all four fields, detection of the motion vector is not just more accurate, but also it becomes possible to allocate vectors to the regions c and e of the picture. The processing applied to each of the different regions a to g shown on Figure 2 is as follows:

Regions a and g : The motion vector of the background gives a low assignment error across all four fields, so four-field interpolation may be used.

Region b : The motion vector of the background gives a low assignment error between the central fields, but not across all four; two-field interpolation across the central fields is used, or possibly extrapolation of the field at time t if the assignment error across the first two fields is smaller than that across the central fields.

E

- Region c: The background vector gives a low error across the first two fields only; no other vectors give a low assignment error across any time period. The area is thus flagged as 'obscured' and extrapolated from the field at time t using the background vector.
- Region d: The motion vector of the object gives a low four-field assignment error, so four-field interpolation is used.
- Region e: The background vector gives a low assignment error over the last two fields; no other vectors give a low assignment error across any time period. The area is thus flagged as 'revealed' and extrapolated from the field at time $t + 1$ using the background vector.
- Region f: The background vector gives a low assignment error between the central fields but not across all four; two-field interpolation across the central fields is thus used, or possibly the field at time $t + 1$ is extrapolated if the assignment error across the last two fields is smaller than that across the central fields.

Thus vector assignment is possible for all the image regions illustrated whether on a pixel-by-pixel or a block-by-block basis. Regions corresponding to obscured background are generated using only information in preceding fields, and information in areas of revealed background using only following fields.

The manner in which the assignment errors are generated will now be described. Four fields of the video signal are made available simultaneously by suitable storage. For each trial vector, the four values along the proposed motion trajectory are determined (see Figure 2). The values taken are the luminance values of the signal. The motion vector may be determined to an accuracy of better than one pixel and when this is the case the motion trajectory will not pass exactly through existing sample positions on fields $t - 1$, $t + 1$ or $t + 2$. A spatial interpolator is then used to calculate the luminance values appertaining to the

nearest pixel positions in those fields.

The four values thus obtained are passed through a high-pass filter which measures the amplitude of the time-varying luminance component. Many filter responses are possible but an example of a possible filter response which provides a weighted average of the modulus of the differences is:

$$0.25 \times \{|a_{-1} - a_1| + |a_0 - a_2|\} \\ + 0.125 \times \{|a_{-1} - a_0| + 2|a_0 - a_1| + |a_1 - a_2|\}$$

Thus a value is obtained for each pixel position. The values across the image are then smoothed by being applied to a spatial low-pass filter, to form a four-field vector assignment error for each vector. For each pixel the magnitudes of the four-field vector assignment errors for all the possible trial vectors are then compared. If the magnitude of the lowest four-field vector assignment error is below a given threshold, then the corresponding vector is assigned to that pixel and the pixel is flagged as undergoing a simple translational motion.

If the lowest four-field assignment error is above this threshold, then the differences between successive fields are examined for all the trial vectors in order to determine which vector and time period gives the lowest error, as described above with reference to Figure 3. For example, if the region corresponds to revealed background, then $|a_1 - a_2|$ would be expected to have a small amplitude for the correct motion vector, whereas $|a_0 - a_1|$ and $|a_{-1} - a_0|$ would be high. Similarly, a region of obscured background would give rise to a low amplitude of $|a_{-1} - a_0|$. If the lowest value was for the central time period, then it might be concluded that the region had just been revealed or was about to be obscured. The three errors are subjected to a spatial filter and preferably multiplied by weighting factors before they are compared. The weighting factors are chosen to ensure that an area is flagged as revealed or obscured background only when the error for one of the outermost field periods is significantly less than for the central period.

2.

A possible hardware implementation of the method of Figure 3 will now be described with reference to Figures 4 to 6. Figure 4 shows how the four luminance values along a trial motion trajectory may be obtained. Three fixed field delays 10 are used to provide signal values from four successive field periods. Variable delay 12 are used to perform the shift in accordance with the trial vector value, multiplied by a value corresponding to the time period between the relevant incoming field and the time for which the vector field is being generated. Such variable delays can be easily implemented using a number of random-access memories addressed by appropriate read and write pointers. In an embodiment where the fields are displaced to sub-pixel accuracy, each shifter is replaced by a number of shifters to provide the values of surrounding pixels; these values are then fed to a spatial interpolator to perform the sub-pixel part of the shift. Such an interpolator is well-known.

Figure 5 shows a possible arrangement for calculating four-field and two-field assignment errors from the luminance values calculated in Figure 4. The errors are calculated using subtractors 14 followed by circuits 16 to calculate the modulus of the field difference. The modulus differences are spatially filtered to form the two-field errors; these are used to calculate the four field error. Integrated circuits are available that could be used to perform such spatial filtering; an example is the Inmos A110. In this example, the four-field error is simply derived in a summer 18 from the sum of the three two-field errors; a more complex high-pass filter arrangement can also be used as explained earlier. These errors are passed to a decision circuit 20, which makes a decision based on the values of the errors in relation to each other and to given threshold values and weighting factors as described earlier. Such a circuit can be constructed from components such as comparators and logic gates.

Figure 6 shows how the classification codes and errors associated with each trial vector are compared in order to arrive at a final decision. This involves comparing the errors for each vector using comparators to determine the smallest. The errors may be weighted prior to comparison depending on their classification;

such a weighting could be carried out by using a programmable read-only memory 22, addressed by the error value and the classification code. The number indicating the chosen vector may be converted easily into the horizontal and vertical vector components of that vector by using the number to address a look-up table containing the list of trial motion vectors.

Image interpolation using the vector and classification information obtained as described above may be carried out easily using an arrangement of field delays and variable delays very similar to that shown in Figure 4. The variable delays are controlled by the chosen vector; the four luminance values obtained are passed to a four-tap filter whose coefficients are determined by the classification code and the temporal position of the field to be generated. Such a filter may be constructed easily using adders and multipliers, together with read-only memories to hold the filter coefficients.

As an alternative to using field differences as a measurement of assignment error, it is possible to form a more accurate measure by taking account of the luminance gradient in the region of each pixel. This allows less weight to be given to errors in highly detailed areas and is advantageous since a small inaccuracy in a motion vector may cause a high field difference in such a region. A suitable method of calculating assignment errors is as follows:-

assignment error = $(| \text{difference} | + \text{const}) / (| \text{gradient} | + \text{const})$

where: difference = $(a_0 - a_1)$ (in the case of the assignment error between the first two fields);

const is a constant whose function is to reduce problems from noise and zero gradients, for example equal to 4 luminance quantisation levels;

and

gradient = square root $\{ (Y(x-1,y) - Y(x+1,y))^2 + (Y(x,y-1) - Y(x,y+1))^2 \}$

where $Y(x,y)$ is the luminance level in the input field closest in time to the time instant at which the

vector field is being generated, (x,y) being the coordinates in this image through which the motion vector under consideration passes.

This technique can be used when calculating any of the assignment errors. The resulting errors are subject to a spatial low-pass filter as described above.

A further possible enhancement to the calculation of assignment errors is to include information from the chrominance signal in addition to that from the luminance as described so far. Two chrominance assignment errors may be calculated in the same way as described for the luminance, by using the so-called U and V chrominance signals. The chrominance assignment errors are then added to that obtained from the luminance component to give a combined assignment error signal which may be more reliable than a luminance-only signal in picture areas with little luminance detail but significant chrominance detail.

If all the assignment errors are large then it can be concluded that no vector matches the motion; the pixel is then flagged as having an unknown vector.

If two or more vectors give similar low assignment errors, it is possible that the incorrect vector may be selected. In practice this is only a problem if the vectors have significantly different values. In one embodiment of the invention, the reliability is improved in this circumstance by repeating the entire assignment process using spatial filters with larger apertures, until a unique vector is found. Alternatively, the spatial filtering of the error signals may be performed in parallel using a plurality of filter apertures and the signal from the smallest filter aperture which gives a unique answer is used. If no unique vector can be found which gives a low assignment error, the pixel is then flagged as having an unknown motion.

More sophisticated methods of combining and weighting the match errors between successive fields may be used to improve the reliability of the vector assignment process. For example, in a preferred embodiment of the invention, seven match errors are calculated from three unweighted match errors as follows:

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First, calculate three unweighted assignment errors E_0 , E_1 and E_2 using the gradient method described above; E_0 being the assignment error between the first two of the four fields determined using $(a_0 - a_1)$, E_1 being between the central two and E_2 being the error between the last two.

Then, calculate seven errors $W_0 - W_6$ based on weighted combinations of E_0 , E_1 and E_2 :

$$\begin{aligned} W_0 &= E_0 * \text{first_wt} \\ W_1 &= E_1 * \text{one_wt} \\ W_2 &= E_2 * \text{second_wt} \\ W_3 &= (E_0 + E_1) / 2 * \text{two_wt} \\ W_4 &= (E_1 + E_2) / 2 * \text{two_wt} \\ W_5 &= (E_0 + E_2) / 2 * \text{two_wt} \\ W_6 &= (E_0 + E_1 + E_2) / 3 * \text{three_wt} \end{aligned}$$

The weighting factors may be constants chosen to optimise the operation of the vector selection process, or may be functions of parameters such as the magnitude of the trial vector, the assignment filter spatial aperture dimensions and the output field position.

In one embodiment, first_wt and second_wt are functions which vary in such a way as to reduce problems at object boundaries when background and foreground vectors compete; in such regions the spatial low-pass filter applied to E_0 - E_2 tends to cause the background vector to be selected just inside the edge of the object. The following formula may be used for these two weighting factors:

$$\begin{aligned} \text{first_wt} &= 1 + (\delta t * \text{vector length}) / \text{aperture length} \\ \text{second_wt} &= 1 + ((1 - \delta t) * \text{vector length}) / \text{aperture length} \end{aligned}$$

where δt is the output field position in the range 0-1 as shown in Figure 3, and aperture length is the size of the spatial filter applied to the assignment errors E_0 - E_2 .

These weighting factors can be limited to a fixed maximum value in the case of very large vectors.

The other weighting factors (one_wt, two_wt and three_wt) are constants chosen to be smaller than unity and so are always less than first_wt or second_wt. This ensures that vectors representing foreground are favoured in relation to those indicating revealed or obscured background. This is because it is subjectively much better for background around the edge of a moving object to be treated as foreground (becoming slightly blurred) than for edges of a foreground object to be treated as background (causing holes to appear in the object).

For each trial vector, the weighted sums W0-W6 are compared and for each sample the smallest is selected. According to this selection, the vector and area classification are made: If W1, W3, W4, W5 or W6 are the smallest, the corresponding vector is assigned and flagged as foreground. If W0 is the smallest, the corresponding vector is assigned and flagged as obscured background. Similarly if W2 is the smallest, the vector is flagged as representing revealed background. As mentioned previously, if the smallest error is above a preset threshold then the pixel may be flagged as having an unknown vector.

The vector and area classification information obtained may be subjected to additional post-processing if required; this may include the use of low-pass or median spatial filters. Such filters are well-known.

As has been noted with reference to Figure 3, the vector and classification information obtained from the operation described above finds particular application in the temporal interpolation of image sequences. Such applications include the generation of high quality slow motion replay, standards conversion between different field-rates, and the interpolation of images in film sequences to increase the display rate to that of television.

Referring again to Figure 3, an output image is shown as being interpolated at an arbitrary time between existing fields. The calculation of the coefficients for the two-field and four-field interpolation filters is a relatively simple and well known process. The figure does not show any regions to which no vector could be

assigned; such regions are interpolated using a non-adaptive four-tap temporal filter, the response of which may be similar to that of the motion-compensation four-tap filter used in regions a, d and g in Figure 3.

In one embodiment of the invention, the vector selection process may be extended to allow up to two vectors to be generated for each output pixel in regions of revealed and obscured background. This allows a soft switch between vectors used for image interpolation at junctions between foreground and background objects. For example, for each pixel that is assigned as revealed background (i.e. the lowest weighted assignment error occurred between the last two fields), the vector giving the minimum assignment error over the first two fields is also determined. The output image is then interpolated from the following fields shifted by the assigned revealed background vector (scaled for the required output time) as previously described, together with a contribution from the preceding fields shifted by this secondary vector. The relative proportion of the two contributions may be determined as follows: A control signal is calculated for each pixel to be interpolated, specifying the fraction of the output image to be taken from the following fields. For all samples in foreground areas, this will be a constant equal to δt in Figure 3, this being the normal mode of operation of a temporal interpolation filter. In a region flagged as revealed background, the control signal will be set equal to unity, since all information should be taken from following fields as described earlier for region e in Figure 3. This control signal is then subject to a low-pass spatial filter, so that it will no longer be equal to unity just inside regions of revealed background.

Both the vector assignment and the temporal interpolation processes have been described without reference to interlace. Both processes can be applied directly to an interlaced signal (taking account of the vertical positioning of the sampled lines); alternatively an interlaced signal can be converted to a sequential or progressive form prior to processing.

It will be appreciated that in the unusual event that it is only desired to detect either obscured background or revealed background, but not both, then only three successive fields need to be compared.

For a block diagram of a slow-motion replay system in which the invention can be incorporated, reference is made to IEE Conference Publication No. 327 (IBC'90) pages 121 to 125, the disclosure which is hereby incorporated by reference, and to the references listed in that paper.

It will also be appreciated that the operations described above will generally be implemented by a computer system rather than by discrete circuitry. The above operational description provides all the information necessary for the production of such a system as will be readily understood by the man skilled in the art, and a detailed description of the programming blocks is therefore unnecessary and is not included here.

CLAIMS

1. A machine method of assigning the appropriate one of a plurality of possible motion vectors to regions of a video image in accordance with apparent movement in that region between a datum field and an adjacent field, comprising the steps of:
determining, for each region of a datum field and for each possible motion vector, image values appropriate to that region for at least four successive fields; and comparing, for each said region, the image values or values derived therefrom for the different motion vectors to determine which motion vector is likely to be appropriate to that region.
2. A method according to claim 1, in which the image values are luminance values.
3. A method according to claim 1, in which the possible motion vectors have an accuracy of better than one pixel, and the step of determining the image values for the adjacent fields comprises spatial interpolation.
4. A method according to claim 1, in which each region comprises one pixel.
5. A method according to claim 1, in which each region comprises a block of pixels.
6. A method according to claim 1, in which the image values are high-pass temporally filtered to provide an assignment error value for each region and each vector, and the comparison comprises comparing assignment error values.
7. A method according to claim 6, in which when for any region one assignment error value only is below a threshold, the corresponding vector is assigned to that region.

8. A method according to claim 7, in which when for any region there is no assignment error value which is below the threshold, the step of comparing further comprises calculating successive inter-field differences for each possible vector and assigning motion vectors in dependence upon the said differences.
9. A method according to claim 8, in which the differences are subjected to spatial filtering.
10. A method according to claim 8, in which the differences are subjected to weighting factors.
11. A method according to claim 8, in which four successive fields are examined (two central fields and two opposed outer fields).
12. A method according to claim 11, in which when the difference between the central fields is below a threshold, but the difference between one of the outer fields and the adjacent central field is high, at least the said one of the outer fields is ignored in assigning the motion vectors.
13. A method according to claim 11, in which when the difference between the central fields is high, the difference between the previous outer field and the adjacent central field is high, and the difference between the following outer field and the adjacent central field is low, the region is identified as revealed background.
14. A method according to claim 13, in which the vector giving the lowest assignment error between the previous outer field and the adjacent central field is also determined and identified as belonging to foreground material adjacent to the region of identified revealed background.

15. A method according to claim 11, in which when the difference between the central fields is high, the difference between the following outer field and the adjacent central field is high, and the difference between the previous outer field and the adjacent central field is low, the region is identified as obscured background.

16. A method according to claim 14, in which the vector giving the lowest assignment error between the following outer field and the adjacent central field is also determined and identified as belonging to foreground material adjacent to the region of identified obscured background.

17. A method according to claim 1, further comprising generating an output field intermediate in time between the input fields by motion-compensated interpolation using the motion vectors thus assigned.

18. A method according to claim 15, in which a soft switch is performed between interpolation in areas of revealed or obscured background and areas of foreground by using two vectors determined in such revealed or obscured regions to shift the preceding and following fields in the interpolator.

19. A method according to claim 1, in which the assignment errors are determined substantially from the ratio of luminance difference values to the local luminance gradient.

20. A method according to claim 1, where the chrominance difference values along a motion trajectory are used in addition to luminance difference values in calculating an assignment error.

21. A method according to claim 1, in which a plurality of weighted assignment errors are formed by combination of the assignment errors between adjacent fields, and the combined errors are examined when determining whether the region corresponds to foreground, revealed or obscured background.

22. A method according to claim 1, in which the vectors are assigned at an arbitrary time in relation to the original images.

23. Apparatus for assigning the appropriate one of a plurality of possible motion vectors to regions of a video image in accordance with apparent movement in that region between a datum field and an adjacent field, the apparatus comprising: means for determining, for each region of a datum field and for each possible motion vector, image values appropriate to that region for at least four successive fields; and means connected to the determining means for comparing, for each said region, the image values or values derived therefrom for the different motion vectors to determine which motion vector is likely to be appropriate to that region.

24. A machine method of assigning the appropriate one of a plurality of possible motion vectors to regions of a video image in accordance with apparent movement in that region between a datum field and an adjacent field, comprising the steps of: determining, for each region of a datum field and for each possible motion vector, image values appropriate to that region for the datum field and at least two adjacent fields; and comparing, for each said region, the image values or values derived therefrom for the different motion vectors to determine which motion vector is likely to be appropriate to that region.

25. A method according to claim 24, in which the vectors are assigned at an arbitrary time in relation to the original images.

26. Apparatus for assigning the appropriate one of a plurality of possible motion vectors to regions of a video image in accordance with apparent movement in that region between a datum field and an adjacent field, the apparatus comprising: means for determining, for each region of a datum field and for each possible motion vector, image values appropriate to that region for the datum field and at least two adjacent fields; and means connected to the determining means for comparing, for each said

region, the image values or values derived therefrom for the different motion vectors to determine which motion vector is likely to be appropriate to that region.

27. Apparatus according to claim 26, in which the vectors are assigned at an arbitrary time in relation to the original images.

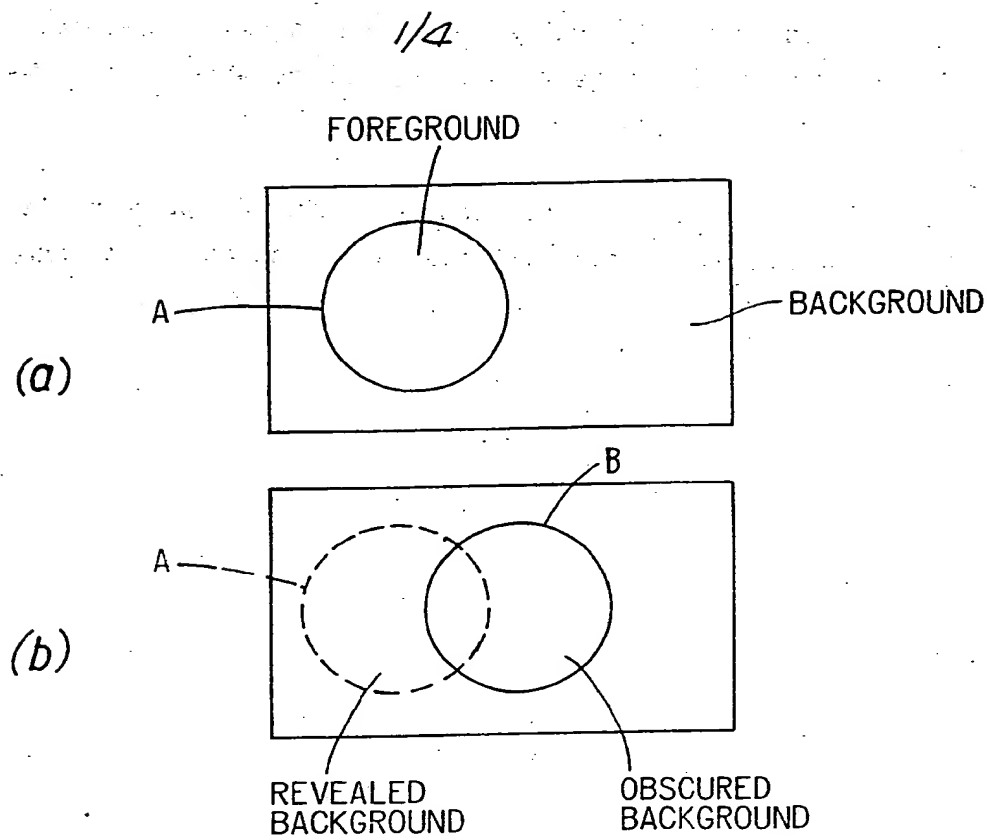


FIG. 1

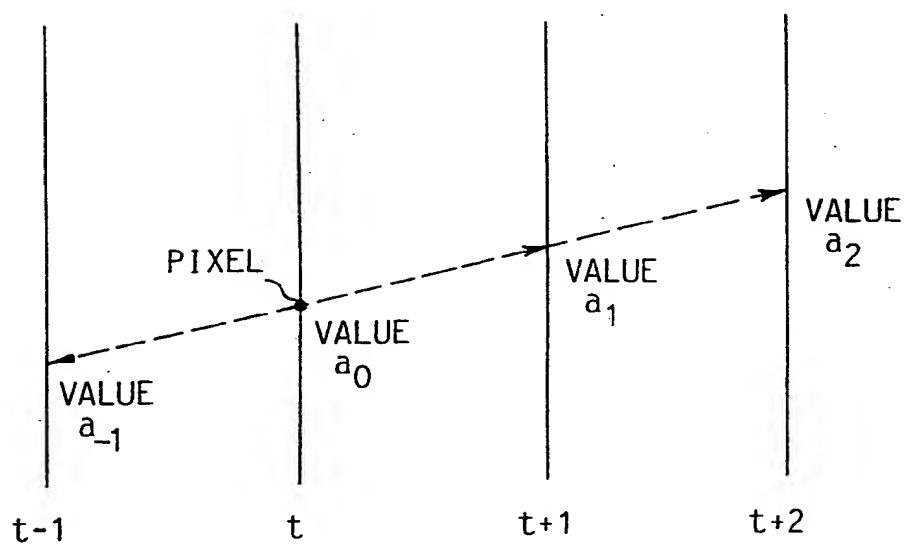


FIG. 2

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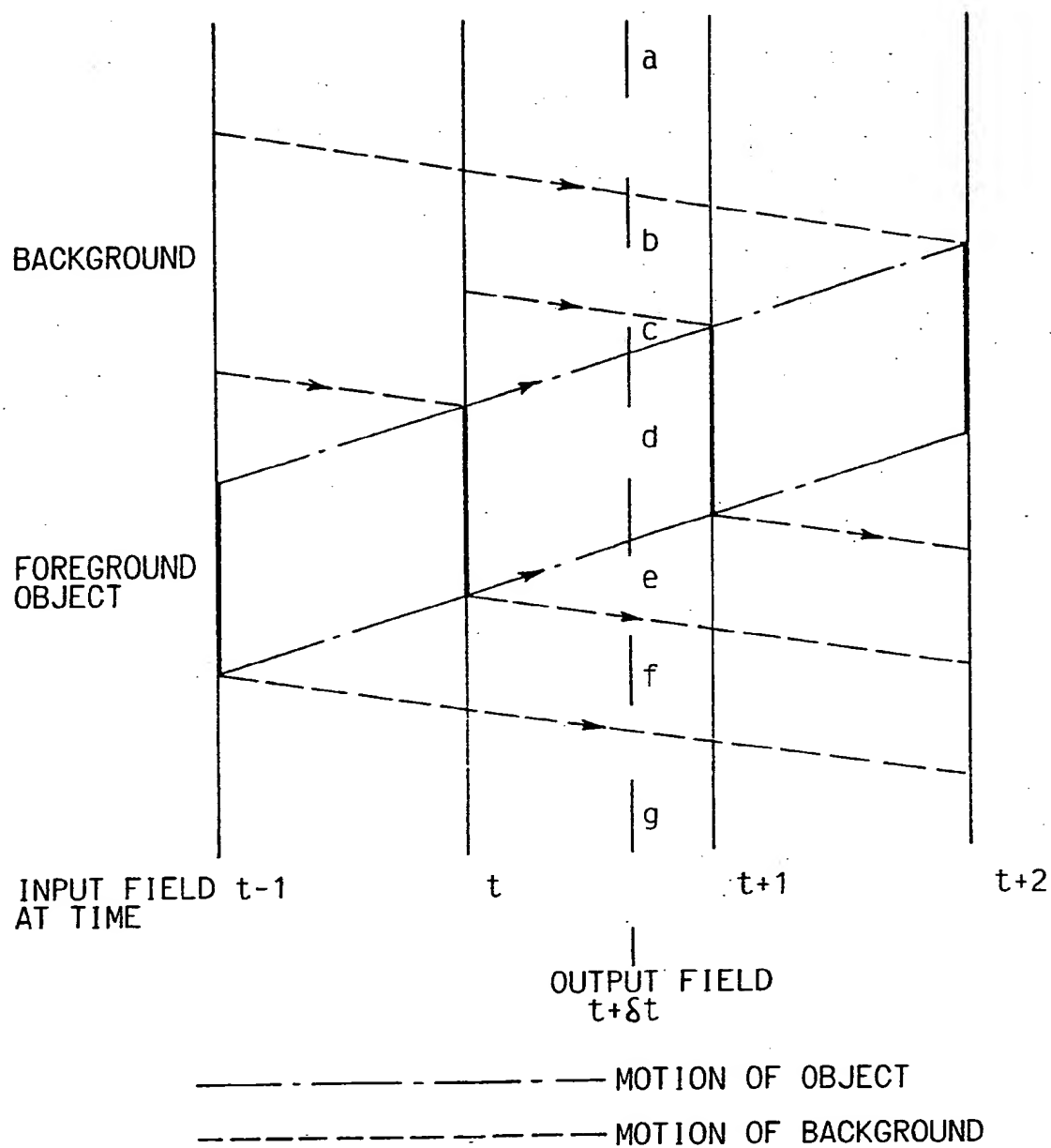


FIG. 3

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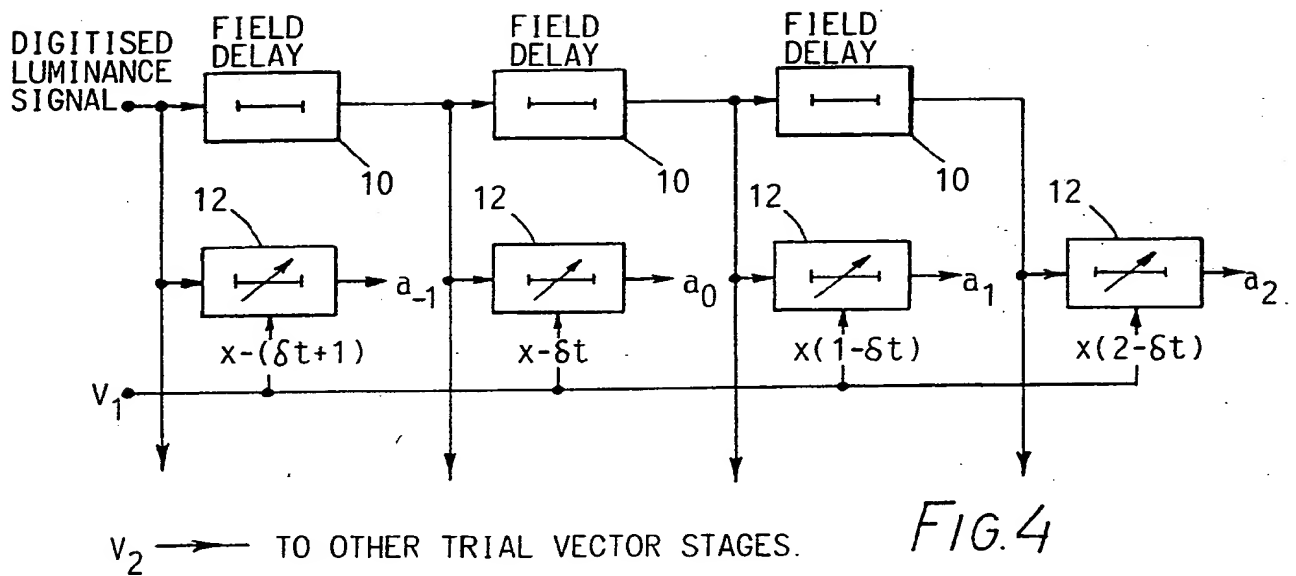


FIG. 4

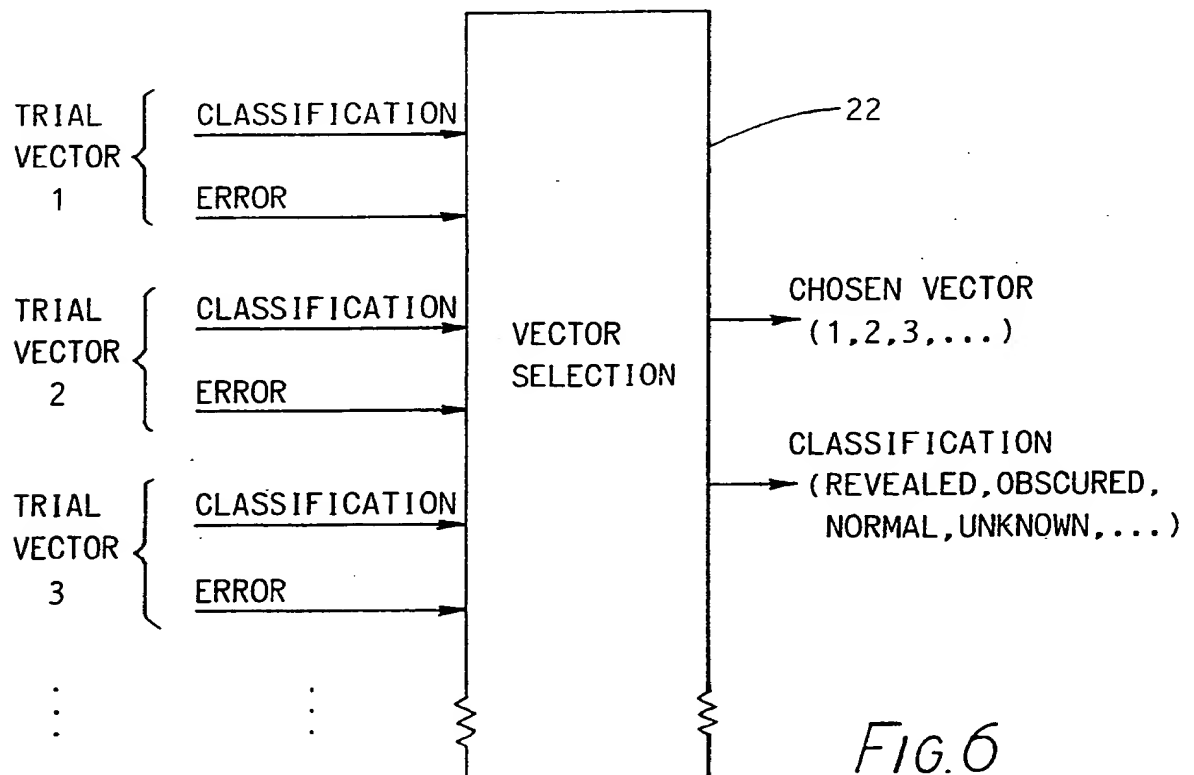


FIG. 6

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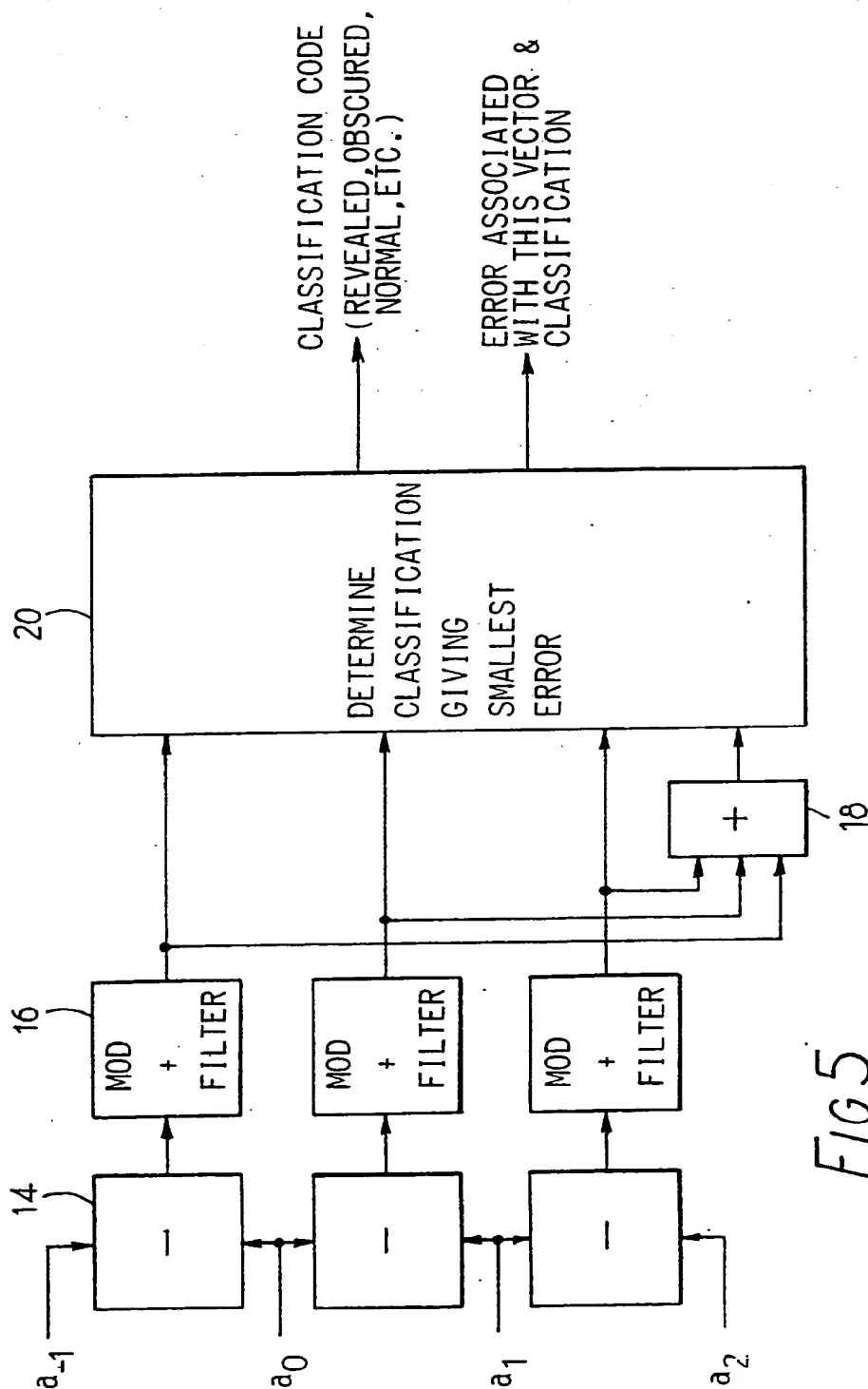


FIG. 5

INTERNATIONAL SEARCH REPORT

PCT/GB 91/01621

International Application No

| | | |
|---|---|-------------------------------------|
| I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ | | |
| According to International Patent Classification (IPC) or to both National Classification and IPC | | |
| Int.Cl. 5 H04N5/14; G06F15/70 | | |
| II. FIELDS SEARCHED | | |
| Minimum Documentation Searched ⁷ | | |
| Classification System | Classification Symbols | |
| Int.Cl. 5 | H04N ; G06F | |
| Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸ | | |
| III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹ | | |
| Category ¹⁰ | Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹² | Relevant to Claim No. ¹³ |
| A | EP,A,0 294 961 (SONY) 14 December 1988 see column 20, line 9 - line 19 see column 21, line 17 - line 25; figures 11,12 --- | 1-6, 23-26 |
| A | EP,A,0 344 843 (PHILIPS) 6 December 1989 see column 5, line 22 - line 37; figures 2,3 --- | 1 |
| <p>¹⁰ Special categories of cited documents : ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> | | |
| IV. CERTIFICATION | | |
| Date of the Actual Completion of the International Search | Date of Mailing of this International Search Report | |
| 02 JANUARY 1992 | 14. 01. 92 | |
| International Searching Authority | Signature of Authorized Officer | |
| EUROPEAN PATENT OFFICE | YVONNET J.W. <i>Yvonne</i> | |

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ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. GB 9101621
SA 51583

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 02/01/92

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---------------------|----------------------------|---------------------|
| EP-A-0294961 | 14-12-88 | EP-A- 0294956 | 14-12-88 |
| | | EP-A- 0294957 | 14-12-88 |
| | | EP-A- 0294960 | 14-12-88 |
| | | EP-A- 0294962 | 14-12-88 |
| | | GB-A, B 2205706 | 14-12-88 |
| | | GB-A, B 2205708 | 14-12-88 |
| | | GB-A, B 2205710 | 14-12-88 |
| | | GB-A, B 2205711 | 14-12-88 |
| | | GB-A, B 2205712 | 14-12-88 |
| | | JP-A- 63313987 | 22-12-88 |
| | | JP-A- 63313980 | 22-12-88 |
| | | JP-A- 63313981 | 22-12-88 |
| | | JP-A- 63313983 | 22-12-88 |
| | | JP-A- 63313984 | 22-12-88 |
| | | US-A- 4862260 | 29-08-89 |
| | | US-A- 4864393 | 05-09-89 |
| | | US-A- 4864398 | 05-09-89 |
| | | US-A- 4864394 | 05-09-89 |
| | | US-A- 4862259 | 29-08-89 |
| EP-A-0344843 | 06-12-89 | AU-A- 4137089 | 22-03-90 |
| | | EP-A- 0359334 | 21-03-90 |
| | | JP-A- 2026484 | 29-01-90 |
| | | JP-A- 2114784 | 26-04-90 |
| | | US-A- 4979036 | 18-12-90 |
| | | US-A- 5027206 | 25-06-91 |

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82